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INFLUENCE OF ENVIRONMENTAL FACTORS ON THE PERFORMANCE OF BEEF STEERS

by

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INTRODUCTION

It is generally assumed that the overall performance of cattle, with respect to such factors as gain in weight, efficiency of gains, efficiency of feed utilization and grade, is affected chiefly by the quantity and quality of feed consumed and the character of the animals in question. Also, environmental factors are believed to have either direct or indirect influence on economically important functions in livestock.

The state of Kansas which is approximately 80,000 square miles has a wide variety of soils and climates. The state is covered with soil (a mineral-organic layer) that varies widely in thickness, color, particle size, chemical fertility, productivity and biological characteristics. These factors are in turn dependent on the kind of geologic material, climate, relief, natural vegetation, length of time of weathering and the activities of man. Since soils are products of those factors, it can be expected that wherever they differ, the soils will be dissimilar. The wide variations in these factors in Kansas have thus produced many different kinds of soils.

Climatic factors, particularly temperature and rainfall, both in total amount and its seasonal distribution, largely determine the range of crops that may be grown successfully in a given area. From a Kansas average annual precipitation map, it is clear that there is a gradual decrease of precipitation toward the high plains area of western Kansas. Bark (1963) stated that starting from the Missouri border on the East, the annual precipitation decreases one inch for about every seventeen miles of travel westward.

Some people think that the performance of cattle may differ in various parts of the state due to location, soil, climate, rainfall and feed produced. The Kansas Experiment Station, therefore, set up experiments to determine whether such differences do exist, and if so, to measure them. In previous studies on this project, Koch et al. (1958) found that animals receiving forage from limestone soil did gain at a faster rate than those receiving forage from sandstone soil. In a later study, Koch et al. (1959) also concluded that trace mineral supplementation is not of any value when beef calves graze on native pasture growing on sandstone soil in Kansas, and that available data did not indicate that Kansas soils and feeds were deficient in trace minerals.

With this background, an aspect of the study entitled "Influence of environmental factors on the performance of beef steers" was set up in 1962. The primary objective of the study was to determine the wintering, fattening and overall performance of beef steers fed in four different geographical areas of the state (but with identical feeding and management), as measured by rate of gain and carcass characteristics.

The study was carried out for three years at Colby, Garden City, Manhattan and Mound Valley experiment stations. The locations had comparable feeding facilities, but varied in soil and climatic environment. The positions of the four locations in the state are shown in Fig. 1, their climatic characteristics in Table I and soil characteristics in Table 2.

This report gives a summary of the results obtained in the three years study.

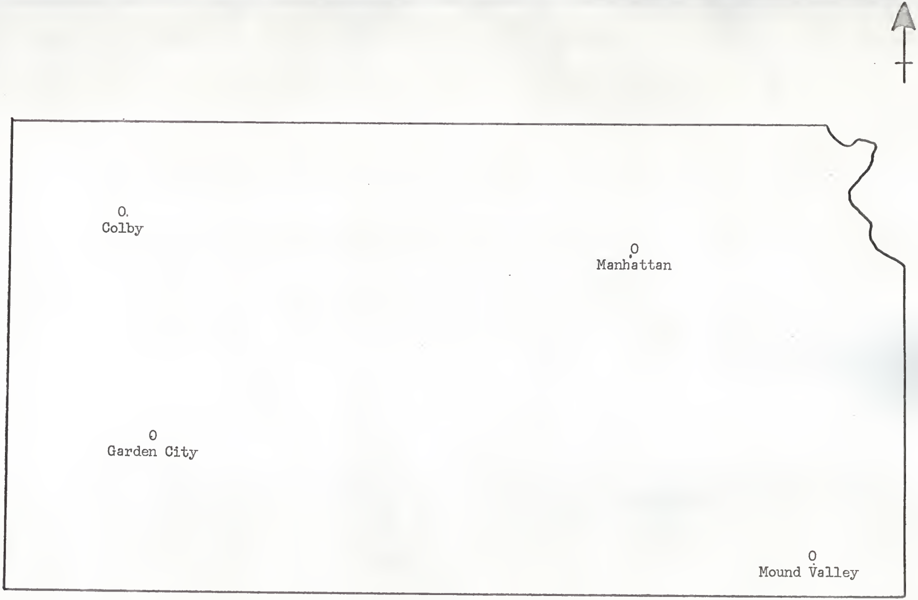

Fig. 1. Map of the State of Kansas showing the four locations selected for the beef environmental study.

Table 1. Annual average climatological data for Colby, Garden City, Manhattan and Mound Valley.*

Location	Altitude ft.	Rainfall in.	Relative Humidity %	Temperature, Degrees F.		
				Mean	Min.	Max.
Colby	3138	18.19	61	50.8	36.0	65.8
Garden City	2882	18.67	63	55.4	42.6	67.3
Manhattan	1106	31.64	67	53.5	41.3	65.7
Mound Valley	800	39.00	67	58.7	46.3	71.1

*Climatography of the United States No. 86-12, 1964: Climatic Summary of the United States Supplement for 1951 Through 1960.

Table 2. Some characteristics of the soils of Colby, Garden City, Manhattan and Mound Valley.

Location	Principal soil type	Parent material	Minimum depth to bed rock (inches)	Sub soil permeability	Soil slope	Best land use	Problems
COLBY	Keith Silt Loam	Loess	140-300	Moderate	Level to rolling	Wheat, Sorghum	Erosion
	Colby Silt Loam	Loess	60-140	Moderate	Undulating to rolling	Wheat, Sorghum, Pasture	Erosion high PH
GARDEN CITY	Keith Silt Loam	Loess	140-300	Moderate	Level to rolling	Wheat, Sorghum, Pasture	Erosion
	Hoisington Silty Clay Loam	Alluvium	60-140	None	Nearly Level	Pasture	Fonding, Poor structure, Soluble Salts
MANHATTAN	Sogn Silty Clay Loam	Limestone & Calcerous	2-20	Moderate	Rolling to hilly	Pasture	Erosion, Shallow soils
	Summit Silty Clay Loam	Limestone & Calcerous	48-60	Moderately slow	Undulating to rolling	Pasture, (some wheat, corn, sorghum legumes)	Erosion, Acidity
	Florence Cherty Silty Clay Loam	Cherty Limestone	24-60	Moderate	Undulating to rolling	Pasture	Erosion, Shallow, Cherty Soils

Table 2 (concl.).

Location	Principal soil type	Parent material	Minimum depth to bed rock (inches)	Sub soil permeability	Soil slope	Best land use	Problems
MANHATTAN (cont.)	Idana Silty Clay Loam	Shales, Loess	60-72	Slow to very slow	Undulating	Wheat, Sorghum, Pasture, Legume	Erosion, Acidity
	Parsons Silt Loam	Acid Shales	30-72	Very slow	Level to undulating	Row Crops, Small Grain, Legume	Erosion, Acidity
MOUND VALLEY	Dennis Silt Loam	Sandy, Silty Clayey Shales	36-48	Moderately slow	Undulating	Pasture	Low Permeability
	Bates Loam	Sandstone & Sandy Shales	48-72	Moderate	Undulating to rolling	Pasture	Low Permeability

*Kansas Agric. Expt. Stn. Circular--336 July, 1956.

REVIEW OF LITERATURE

Environmental Effects on Vegetation

Vegetation has long been known to be the product of its environmental factors. Soils, topography and climate are among the important physical factors that have the greatest effect on the type and quality of vegetation that grows in any place. Acknowledging this fact, Beardsley (1964) noted in his study that various factors, such as stage of maturity, weather conditions and equipment used, often have more influence on the feeding value of a forage than the particular method of harvesting and storing used. Also, Bonnen (1960) attributed the diversity of farming in Texas to the wide differences in the physical factors of soils, climate and topography all over the state.

Because of their specific biologic characteristics and habits of growth, some crops are affected particularly by soil depth and texture, plant food content, water holding capacity or height of the water table. Almost any crop will make some growth on any type of soil provided ample soil moisture is available, but certain crops do better than others on a particular type of soil. It is in deference to this fact that soil maps of different places are prepared with recommendations of the types of crops best suited to each soil type. The results of the study by Stubblefield and De Turk (1940) clearly showed that soil fertility and fertilization affected the composition of grain.

Doty et al. (1943) found that soil type and location produced a significant effect on the protein content of corn grain. McElroy et al. (1949) studied the effect of soil on the essential amino acids in oat protein and found that as the percentage of total nitrogen in the oats was increased by the higher nitrogen content of the soil, the amount of lysine (as a percentage of total nitrogen) decreased. Concluding from their extensive study, McCalla and Corns (1943) stated that the protein content of wheat and barley depended considerably on environmental conditions.

Climatic factors, particularly rainfall and temperature, largely determine the range of crops that may be successfully grown in a given area. Temperature affects crop production in many ways, but mainly through the length of the growing season.

In agreement with the reports of Burleson et al. (1959), Gipson et al. (1960) and Mathers et al. (1960), a three year study by Lyles and Fanning (1965) showed no statistically significant differences in grain yields among six fertilizer treatments of non-irrigated grain sorghum. Interpreting their results, they concluded that non-irrigated grain sorghum yields in the Low Rio Grande Valley depended more on available soil moisture than on fertilizer application. They further stated that unless adequate moisture is available, one can seldom expect a yield response to fertilizer. Thus in this experiment, as in many others of its type, the importance of moisture in plant growth and yield was evident.

Effect of Temperature and Humidity on Animal Performance

The belief that temperature and humidity affect the performance of animals is not a new one. Recognition of this fact is evident by the widespread use of Brahman and Brahman crossbreds cattle in hot, humid areas because of their greater adaptability to such conditions as opposed to the keeping of Herefords in temperate zones.

Many experiments have demonstrated that exposure of animals to cold results in increased food intake. Kleiber and Dougherty (1934) showed that when chicks were fed a diet of constant composition at decreasing environmental temperatures, the intake of metabolizable energy increased progressively from 200 kilo calories per day per kilogram of body weight at $40^{\circ}C$ to 300 kilo calories per day per kilogram of body weight at $20^{\circ}C$. They noted that net energy had a maximum between $30^{\circ}C$ and $40^{\circ}C$ and growth rate was maximal at $21^{\circ}C$.

Tredwell et al. (1957) demonstrated higher growth rates and protein efficiency ratios in rats maintained at $1^{\circ}C$ than at $25^{\circ}C$ for diets containing 5% and 10% protein, but poorer performance for diets containing more than 10% protein. This illustrated that exposure to cold may exert an advantageous effect at some levels of dietary protein but not at others.

Similarly, Meyer and Hargus (1959) noted greater growth rates at $2^{\circ}C$ than at $25^{\circ}C$ for rats fed a 10% casein diet but poorer performance at $2^{\circ}C$ than at $25^{\circ}C$ for rats fed a diet containing 25% casein.

On the other hand, some workers observed that exposure of rats to cold exerts an adverse effect on growth rate. When Sellers et al. (1954) maintained rats at $1.5^{\circ}C$ with diets of various composition (the caloric content of which ranged from 4.1 to 6.2 kilocalories per gram) they found that growth and survival were unaffected by the level of protein, fat or carbohydrate.

Houghton et al. (1964) investigated the possibility of sustaining good growth rates and high feed efficiency with pigs under conditions of high temperature and humidity and concluded that where temperate standards for pigs are used in the humid tropics, there might well be considerable feed wastage.

Jensen (1964) stated that temperature was the most critical factor of physical environment for swine as it has been shown to affect the behavior, rate of gain, feed utilization, carcass composition, certain nutritive requirements and reproductive efficiency of swine.

Payne and Jacob (1965) tested the assumption that protein metabolism was influenced by environmental temperature, provided energy supply was adequate. They exposed 30 day-old rats to environmental temperatures of 15°C and 27°C and fed them diets containing 4, 10 and 25% protein. It was observed that at 15°C rats fed the 4% protein diet grew slightly better, and those fed the 10% protein diet markedly better than those fed the same diet at 27°C. In contrast, rats fed 25% protein diet grew more slowly at the lower temperature. At 4 and 10% protein diets, rats exposed to 15°C ate more food and utilized their protein with unimpaired efficiency, thus gaining more weight than those exposed to 27°C. However, rats fed the 25% protein diet were unable to utilize their dietary protein at full efficiency and gained less weight. They observed that the effect of temperature on carcass composition was very slight.

These findings show that temperature and humidity can, in many ways, affect an animal's performance both physiologically and with respect to rate and efficiency of gains.

Cattle Performance Under Varying Climatic Conditions

Many important functions in livestock are believed to be directly or indirectly affected by climatic environment. Brody (1948) stated that climatic factors exert regulative effects on levels of hormones, enzymes, metabolites, metabolic rates and consequently on the entire physiology, chemistry and economy of the animal. Also, Gangdvar et al. (1965) obtained highly significant differences in the length of estrus cycle of cattle under natural spring climate, cycled hot and natural summer climatic conditions. Duration of estrus was also affected under these climatic conditions.

Bonsma (1947), in his study of the influence of climate on animal production, divided Hereford cattle into three uniform groups and fed them hay and concentrates grown at a common location. The three groups were fed at Messina, Pretoria and Ermelo in South Africa with average annual temperatures of 71.7°F, 61.2°F and 58.5°F, respectively. He found that animals at Ermelo had significantly higher weight gains than those at Pretoria and Messina; and those at Pretoria had significantly higher gains than those at Messina.

Hancock and Payne (1955) divided eight sets of identical twin heifer calves between the Fiji Islands (with hot and humid climate) and New Zealand (with temperate climate) using identical feeding and management practices. They noted a size difference of approximately 10% when the animals were about 24 months of age. They concluded that part of the stunting apparent in European-type cattle in Fiji might be attributed to the direct effect of climate.

In their four-year study on a genotype-environment interaction involving breed and climatic differences and their effect on rate of gain, Rollins et al. (1964) obtained results which showed that the 3/4 Hereford X 1/4 Brahman crossbred calves outgained the pure Hereford calves in the summer, but the reverse was true in the fall and winter.

Kuykendall et al. (1964), in two separate trials, fed cattle at six locations with comparable feeding facilities but varying climatic environment in Texas and obtained no significant differences in weight gains in each year's results. However, when the data from both years were pooled, a significant difference in gains due to locations was observed. Animals at Balmorhea, Beeville and Spur had significantly higher gains than those at McCregor, Angleton and College Station. Of the carcass characteristics studied, only rib eye area per hundred weight of chilled carcass and calculated yield grade tended to differ significantly among locations.

MATERIALS AND METHODS

Experiment One

Wintering Phase. Forty-eight Hereford steer calves averaging 448 pounds were obtained from the Warner Ranch in Rice County, Kansas, in November 1962. The animals were weighed on two consecutive days preceding the start of the experiment to obtain the starting weight of each animal. They were then divided into four lots of twelve animals each, and in such a way that the average weights of the lots did not differ by more than one pound. One lot was assigned to each of four locations: Colby, Garden City, Manhattan and Mound Valley. The animals in each location were subdivided into two groups of six animals to reduce competition effects and pick up small differences due to treatments.

The wintering phase of the experiment lasted from November 21, 1962 to March 19, 1963, a period of 118 days. All animals were fed sorghum silage (F S 1a hybrid) ad libitum and 5 pounds of second cutting alfalfa hay per head per day. The sorghum silage and alfalfa hay fed in each location were those grown and processed in that particular location. Salt was the only mineral supplied and water was available ad libitum in automatic electrically heated waterers. Uniform-size concrete lots with sheds were used at each location for housing the animals. They were fed twice daily between 7 and 8 a.m. and 4 and 5 p.m. Feed left uneaten was weighed back and recorded in order to know the accurate average feed consumption.

Individual weighing of the animals was done every 28 days. A complete proximate analysis was performed on both the hay and silage used at each location.

Fattening Phase. At the end of the wintering phase, all the animals were weighed on March 18 and 19, 1963 and the average of the two weights used as the final wintering weight and the beginning weight for the fattening phase. The fattening phase lasted from March 19 to September 28, 1963, a period of 193 days.

After the wintering phase, silage was gradually decreased until it was eliminated from the ration. At the same time, locally grown sorghum grain (R S 610) was introduced and gradually increased until the grain was self fed. The 5 pounds of alfalfa hay per head per day was continued and salt and water were provided *ad libitum*. Gradual introduction of the animals to grain and gradual withdrawal of silage was necessary to avoid digestive disturbances that may be caused by a sudden change in diet.

Proximate analysis was also performed on the sorghum grain fed from each location. Table 3 summarizes the important information on the feeds.

The average of the two weights of each animal taken on the last two consecutive days of the experiment was recorded as the finished (feed lot) weight. The animals were slaughtered in Wichita at Excel Packing Plant. Carcass data were collected and liver samples for vitamin A analysis taken from the small lobe.

Table 3. Feedstuff analyses: Experiment I 1962-63.

	Moisture, %	Dry matter, %	Protein, %	Ash, %	Crude fiber, %	Ether extract, %	N.F.E., %	Carotene, mgs./lb.
Colby:								
Sorghum Silage	71.80	28.20	1.82	2.61	5.07	0.84	17.86	8
Alfalfa Hay	5.00	95.00	15.50	6.41	33.32	1.40	38.37	14
Sorghum Grain	11.99	88.01	8.19	2.86	4.07	5.10	67.79	..
Garden City:								
Sorghum Silage	68.56	31.44	1.33	2.00	3.17	0.48	24.46	1
Alfalfa Hay	5.00	95.00	14.28	9.19	29.97	1.62	39.94	38
Sorghum Grain	9.90	90.10	7.35	2.79	2.34	5.20	72.42	..
Manhattan:								
Sorghum Silage	68.49	31.51	1.95	1.54	7.38	0.75	19.89	2
Alfalfa Hay	5.00	95.00	11.98	3.11	35.67	1.19	43.05	10
Sorghum Grain	10.65	89.35	8.14	2.58	3.48	4.50	70.65	..
Mound Valley:								
Sorghum Silage	75.96	24.04	1.80	1.61	3.95	0.39	16.29	2
Alfalfa Hay	5.00	95.00	13.67	5.79	31.01	1.41	43.12	7
Sorghum Grain	7.99	92.01	7.73	2.23	3.41	4.40	74.24	..

Experiment Two

Wintering and Fattening Phases. This experiment was in all respects, except the initial weight of the steer calves, a duplicate of Experiment I. It was conducted the same way as the previous one. The average initial weight of the 48 steer calves, obtained from Warner Ranch, used in the experiment was 454 pounds.

The wintering phase lasted from November 8, 1963 to February 28, 1964, a period of 112 days; and the fattening phase, from February 29 to September 25, 1964, a total of 210 days. The feeding system in both the wintering and fattening phases was similar to that in Experiment I, and the same was true of the frequency of the weighing period.

A complete proximate analysis was made on the feedstuffs used. Table 4 contains a summary of the important information on the feeds.

The animals were slaughtered at the Excel Packing Plant, Wichita, Kansas. Carcass data were collected and liver samples for vitamin A analysis taken from the small lobe.

Experiment Three

Wintering and Fattening Phases. This experiment was similar to the previous two. The average initial weight of the 48 steer calves, obtained from the same herd (Warner's Ranch), used in the experiment was 475 pounds. In this trial, concrete replaced the soil floors under the sheds in order to eliminate muddy conditions.

The wintering phase lasted from November 13, 1964 to March 5, 1965, a period of 112 days and the fattening phase, from March 5 to September 25, 1965, a total of 204 days. The feeding system in both the wintering and

Table 4. Feedstuff analyses: Experiment II 1963-64.

	Moisture, %	Dry matter, %	Protein, %	Ash, %	Ether extract, %	Crude fiber, %	N.F.E., %	Carotene, mgs./lb.
Colby:								
Sorghum Silage	72.14	27.86	1.71	2.42	0.59	6.60	16.54	1.0
Alfalfa Hay	5.2	94.8	13.69	7.65	1.68	26.78	45.00	29.2
Sorghum Grain								
Dryland	8.5	91.5	9.81	0.91	0.99	0.92	78.87	....
Irrigated	8.5	91.5	10.84	0.93	1.91	1.91	75.91	....
Garden City:								
Sorghum Silage	69.0	31.0	1.76	2.42	0.65	7.45	18.72	2.0
Alfalfa Hay	6.9	93.1	19.18	9.14	1.55	24.90	38.33	24.9
Sorghum Grain	10.7	89.3	8.52	0.77	3.93	1.93	74.15	....
Manhattan:								
Sorghum Silage	65.60	34.4	3.15	2.98	1.01	8.52	18.74	2.0
Alfalfa Hay	6.50	93.5	16.71	7.32	2.41	24.74	42.32	17.6
Sorghum Grain	12.10	87.9	9.97	0.95	2.76	1.47	72.75	....
Mound Valley:								
Sorghum Silage	71.70	28.3	1.88	1.91	0.63	6.44	17.42	1.0
Alfalfa Hay	6.70	93.3	18.58	9.63	1.82	22.70	40.57	8.8
Sorghum Grain	11.30	88.7	9.46	1.02	1.53	2.34	74.35	....

fattening phases was identical to that in the previous experiments, and so also was the interval of the weighing period.

A complete proximate analysis was made on the feedstuffs used. Table 5 gives a summary of the important information on the feeds.

The animals were slaughtered at the Excel Packing Company in Wichita, Kansas. Carcass data were obtained. Liver samples were not taken because the animals in Mound Valley were erroneously injected with synthetic vitamin A when a vitamin A deficiency was noted. This would make liver vitamin A storage comparisons of the four locations useless.

Chemical Analysis of the Feed

Feed samples of the hay, silage and grain used for the trial each year were collected and a proximate analysis was run. The revelant procedures as outlined in the A.O.A.C. (1960) were used for the analysis. Part of the fresh samples of silage and hay were stored in brown quart-size sampling jars kept in the refrigerator for carotene determination. The A.O.A.C. (1960) procedures were used in the carotene determinations of the silage and hay.

Liver Analysis for Vitamin A and Carotenoids

Liver analysis for vitamin A and cartenoids was done for the 1962-63 and 1963-64 trials. The method used was the routine procedure in the University's Animal Nutrition Laboratory which is a slight modification of the method of Heaton et al. (1957) that probably developed from the old method of Savies (1933).

To a 5-10 g sample of liver, 10 ml of 50% (w/v) potassium hydroxide and 10 ml of 95% ethyl alcohol were added. The mixture was heated gently under

Table 5. Feedstuff analyses: Experiment III 1964-65.

	Dry matter, %	Moisture, %	Protein, %	Ash, %	Ether extract, %	Crude fiber, %	N.F.E., %	Carotene, mgs./lb.
Colby:								
Sorghum Silage	32.09	67.91	1.95	2.01	0.66	6.86	20.61	2.28
Alfalfa Hay	94.17	5.83	17.01	9.70	1.84	30.25	35.37	9.23
Sorghum Grain	88.54	11.46	10.71	2.86	1.05	1.09	72.83	.....
Garden City:								
Sorghum Silage	35.77	64.23	1.58	2.57	0.52	5.67	25.43	3.05
Alfalfa Hay	90.80	9.20	13.46	8.89	2.57	29.97	35.91	37.69
Sorghum Grain	87.28	12.72	9.23	1.06	1.59	1.82	73.58	.....
Manhattan:								
Sorghum Silage	35.77	64.23	1.84	1.29	0.70	6.87	25.07	1.07
Alfalfa Hay	91.73	8.27	22.54	7.48	2.57	26.59	32.55	5.34
Sorghum Grain	87.32	12.68	10.19	1.78	2.38	1.84	71.19	.....
Mound Valley:								
Sorghum Silage	35.77	64.23	2.47	1.90	0.67	7.15	23.58	0.72
Alfalfa Hay	94.96	5.04	19.96	5.96	2.75	33.45	32.84	5.11
Sorghum Grain	88.34	11.66	9.69	1.55	2.66	1.89	72.48	.....

reflux for 30 minutes. It was then extracted twice with dry ether in two separatory funnels, once with 50 ml and once with 40 ml. The extract was washed free of alkali and alcohol and then dried with anhydrous sodium sulfate. The yellow color (carotenoids) of the solution was read at 440 millimicrons and vitamin A was determined by use of Carr-Price reagent. To check on the ether used for freedom from peroxides, a procedure as follows was made: a known amount of vitamin A standard was dissolved in the ether and let settle for 2 hours (the length of time required for an extraction of vitamin A in the liver). The recovery of the vitamin A was then determined by use of Carr-Price reagent. Since the recovery was 100%, no further treatment of the ether was necessary.

RESULTS

Observations on the Live Animals During Trial Period

In all of the trials, the animals came through the wintering and fattening periods in very good condition. Weight gains at all locations for the three years were efficient and economical.

Despite the precaution of the gradual increase of the animal's grain consumption, some animals had digestive disturbances during their first month on grain. The disturbance was in no way serious enough to affect the animals' performance.

During the 1964-65 study, some animals in Manhattan were treated for foot rot. They responded very well to treatment and suffered no drastic weight loss as a result. At Mound Valley, some of the animals were partially blind and a few totally blind. Since their weight gains were comparable to the healthy ones in the lot, indicative that they were able to find feed and water, they were not culled. There was one case of urinary calculi at Colby.

In general appearance, the animals in all locations were about the same except for the Mound Valley ones in the 1964-65 trial which were slightly below the others. As evidence of this, the packing company paid one cent per pound less for Mound Valley animals than for the others. Throughout the three years study, very good management was practiced and there were no losses.

Summary Results of Wintering and Fattening Phases

Table 6 is a summary of the results obtained during the wintering phase of the 1962-63 trial. In like manner, Tables 7 and 8 give the wintering phase results for the 1963-64 and 1964-65 trials, respectively. They include information on average daily gains, average daily rations and feed cost per hundred weight gain.

Tables 9, 10, and 11 contain similar information obtained during the fattening phase for the 1962-63, 1963-64 and 1964-65 trials, respectively. In addition, each of the tables contains summaries of the carcass data for each year.

A detailed discussion of the results of each of the traits being measured is given in subsequent paragraphs.

Wintering Gain

Two out of the three yearly analyses of variance showed significant differences ($P < .05$) among the locations with respect to wintering gain. Examination of the means showed that significantly higher gains were obtained at Mound Valley in the 1962-63 trial. There were no significant differences

Table 6. Feedlot results for wintering phase, November 21, 1962 to March 19, 1963--118 days 1962-63 Trial.

Location	Colby		Garden City		Manhattan		Mound Valley	
Lot no.	1	2	1	2	1	2	1	2
No. steers per lot . . .	6	6	6	6	6	6	6	6
Av. initial wt., lbs. .	448	448	449	448	449	449	449	448
Av. final wt., lbs. . .	585.8	567.5	588.3	584.8	581.7	592.5	611	611
Av. daily gain, lbs. . .	1.17	1.01	1.18	1.16	1.12	1.21	1.37	1.38
Av. daily ration, lbs.:								
Sorghum silage	24	24	22	22	23	23	30	29
Alfalfa hay	5	5	5	5	5	5	5	5
Feed per cwt. gain, lbs.:								
Sorghum silage	2,082	2,376	1,853	1,873	2,045	1,895	2,187	2,135
Alfalfa hay	418	490	422	430	445	412	365	363
Dry matter per cwt. gain, lbs.:								
Sorghum silage	618	706	584	590	644	597	538	525
Alfalfa hay	397	465	401	408	423	391	347	345
Total dry matter per cwt. gain, lbs.	1,015	1,171	985	998	1,067	988	885	870
Feed cost per cwt. gain[1]	$11.99	$13.85	$11.30	$11.47	$12.21	$11.31	$11.67	$11.48

[1] Silage $6.50 per ton; alfalfa hay $25.00 per ton.

Table 7. Results of the wintering phase, November 8, 1963 to February 28, 1964--112 days. 1963-64 Trial.

Location	Colby		Garden City		Manhattan		Mound Valley	
Lot no.	1	2	1	2	1	2	1	2
No. steers per lot	6	6	6	6	6	6	6	6
Av. initial wt., lbs.	454.2	454.2	453.3	454.2	453.3	454.2	454.2	453.3
Av. final wt., lbs.	572.1	590.1	649.0	616.8	619.2	607.5	608.5	575.7
Av. daily gain, lbs.	1.05	1.21	1.75	1.45	1.48	1.37	1.38	1.09
Av. daily ration, lbs.:								
Sorghum silage	25.2	27.1	23.8	22.3	24.5	24.1	22.8	20.3
Alfalfa hay	4.3	5.0	4.9	4.9	5.0	5.0	5.0	5.0
Feed per cwt. gain, lbs.:								
Sorghum silage	2,389	2,233	1,360	1,534	1,656	1,760	1,658	1,858
Alfalfa hay	405	408	278	334	338	365	362	454
Total dry matter per cwt. gain, lbs.	954	921	680	786	886	947	807	949
Feed cost per cwt. gain[1]	$14.62	$14.03	$ 8.92	$10.31	$11.05	$11.60	$11.16	$13.11

[1] Silage $8.00 per ton; alfalfa hay $25.00 per ton.

Table 8. Feed lot results for wintering phase, November 13, 1964 to March 5, 1965--112 days. 1964-65 Trial.

Location	Colby		Garden City		Manhattan		Mound Valley	
Lot no.	1	2	1	2	1	2	1	2
No. steers per lot . . .	6	6	6	6	6	6	6	6
Av. initial wt., lbs. .	475	475	475	477	476	476	471.8	479.2
Av. final wt., lbs. . .	615	612	598.2	602.2	620	607.5	662.2	672.2
Av. daily gain, lbs. . .	1.25	1.22	1.10	1.12	1.29	1.18	1.70	1.72
Av. daily ration, lbs.:								
Sorghum silage	28.9	30.9	23.6	24.2	22.0	22.0	24.6	26.3
Alfalfa hay	4.5	3.7	4.7	4.9	4.9	5.0	4.7	4.2
Feed per cwt. gain, lbs.:								
Sorghum silage	2,316	2,540	2,147	2,137	1,712	1,875	1,445	1,525
Alfalfa hay	363	302	399	429	383	424	276	246
Total dry matter per cwt. gain, lbs.	1,085	1,100	1,130	1,154	946	1,060	779	779
Feed cost per cwt. gain[1]	$13.80	$13.94	$13.58	$13.91	$11.64	$12.80	$ 9.23	$ 9.18

[1]Silage $8.00 per ton; alfalfa hay $25.00 per ton.

Table 9. Feedlot results for fattening phase, March 19 to September 28, 1963--193 days. 1962-63 Trial.

Location	Colby		Garden City		Manhattan		Mound Valley	
Initial wt. per steer, lbs.	585.8	567.5	588.3	584.8	581.7	592.5	611	611
Final wt. per steer, lbs.	1,024	965.5	1,026	1,035	995	977.5	945	906
Av. daily gain, lbs.	2.27	2.06	2.27	2.33	2.19	1.99	1.73	1.53
Av. daily ration, lbs.:								
Alfalfa hay	4.6	4.6	4.5	4.4	5.0	5.0	4.5	4.1
Sorghum grain	17.1	16.5	16.9	16.8	15.4	16.0	14.7	13.2
Feed per cwt. gain, lbs.:								
Alfalfa hay	202.2	223.4	197.0	190.4	231.9	249.6	261.9	270.0
Sorghum grain	751.7	800.9	745.8	718.5	720.4	802.0	850.2	862.9
Feed cost per cwt. gain[1]	$16.06	$17.21	$15.88	$15.31	$15.87	$17.56	$18.57	$18.91
Shrink to market, %	5.5	4.2	4.7	3.1	3.9	3.2	4.5	3.8
Av. hot carcass wt. less 2%	602.2	574.8	608.3	610.7	583.6	583.1	546	525
Dressing %, feedlot wt.	58.8	59.5	59.3	59	58.7	59.7	57.8	57.9
Dressing %, selling wt.	62.2	62.1	62.2	61.9	61	61.7	60.5	60.2
Av. finish:								
Fat thickness, 12th rib, in.	.59	.74	.56	.53	.46	.56	.49	.40
Distribution[2]	3.0	3.0	3.2	3.3	3.2	3.2	2.3	3.7
Size rib eye, sq. in.	10.04	9.67	10.64	10.27	10.36	10.12	10.19	9.26
Degree marbling[3]	5.8	6.0	6.5	6.8	6.7	6.2	5.5	6.7
Degree firmness[4]	3.7	4.2	4.3	4.7	4.5	4.2	3.7	4.0
Fat color[5]	2.7	2.7	2.3	2.8	2.5	2.8	2.7	3.2
Lean color[6]	2.5	2.0	3.2	2.5	2.7	2.7	2.7	3.2
Av. carcass grade:								
Av. prime	..	..	..	..	..	..	1	..
Top choice	..	..	..	..	..	..	..	..
Av. choice	1	1	..	..	..	2	2	..
Low choice	5	3	5	3	4	2	1	1

Table 9 (concl.).

Location	Colby		Garden City		Manhattan		Mound Valley	
Top good	..	2	1	2	2	1	1	2
Av. good	..	..	..	..	..	..	1	1
Low good	..	..	..	1	..	1	..	2
Liver wt., lbs.	10.02	10.11	10.48	10.55	10.15	9.69	8.80	8.77
Vitamin A per gram liver, I.U.	155.7	189.1	238.0	151.7	55.4	66.7	59.9	52.6
Carotene per gram liver, mcg.	4.7	5.1	5.9	6.1	4.2	4.2	3.3	3.6

[1]Alfalfa hay $25.00 per ton; sorghum grain, $1.80 per cwt.

[2]2 = uniform, 3 = moderately uniform, 4 = modestly uniform.

[3]5 = moderate, 6 = modest, 7 = small amount.

[4]3 = moderately, 4 = modestly firm, 5 = slightly firm.

[5]1 = white, 2 = creamy white, 3 = creamy, 4 = slightly yellow.

[6]1 = light cherry red or dark pink, 2 = slightly dark cherry red, 3 = moderately dark cherry red, 4 = slightly dark red.

Table 10. Results for fattening phase, February 29 to September 25, 1964--210 days. 1963-64 Trial.

Location	Colby		Garden City		Manhattan		Mound Valley	
Initial wt. per steer, lbs.	572.1	590.1	649.0	616.8	619.2	607.5	608.5	575.7
Final wt. per steer, lbs.	1,077	1,090	1,153	1,078	1,011	1,046	1,029	1,037
Av. daily gain, lbs.	2.40	2.38	2.40	2.20	1.87	2.09	2.00	2.19
Av. daily ration, lbs.:								
Alfalfa hay	4.71	4.98	4.05	4.75	4.78	4.94	4.60	4.65
Sorghum grain	15.77	17.21	16.43	14.88	14.62	14.84	13.53	15.18
Feed per cwt. gain, lbs.:								
Alfalfa hay	196	209	169	216	256	237	230	212
Sorghum grain	656	723	684	677	784	711	676	692
Feed cost per cwt. gain[1]	$14.26	$15.62	$14.42	$14.89	$17.31	$15.76	$15.05	$15.01
Shrink to market, %	2.09	3.29	3.24	2.16	1.65	2.63	2.69	3.20
Av. hot carcass wt., lbs.	664.2	668.7	709.7	662.8	617.3	629.2	616.2	622.7
Av. cold carcass wt., lbs.	649.5	659.2	695.0	648.8	605.7	617.3	600.5	609.2
Dressing %, feedlot wt.	60.33	60.17	60.27	60.17	59.92	59.06	58.39	58.77
Dressing %, market wt.	61.61	62.21	62.29	61.50	60.92	60.62	60.00	60.71
Av. fat thickness, 12th rib, in.	0.78	0.65	0.88	0.64	0.73	0.66	0.44	0.55
Av. size rib eye sq. in.	11.53	11.28	11.97	11.52	11.23	11.02	11.53	11.52
Av. degree marbling[2]	7.0	7.7	6.3	6.7	7.2	7.3	7.7	7.3
Carcass grades:								
Top choice	1	..	..	..	..	1	..	..
Av. choice	1	1	3	..	1	..	1	3
Low choice	3	4	3	6	2	2	1	..
Top good	..	..	..	..	..	..	2	..
Av. good	1	..	..	..	1	2	1	2
Low good	..	1	..	..	2	1	1	1

Table 10 (concl.).

Location	Colby		Garden City		Manhattan		Mound Valley	
Av. liver wt., lbs. . .	11.38	11.04	11.04	9.96	9.83	9.71	10.46	9.75
Vit. A. per gram liver, I.U.	5.25	3.62	5.96	9.63	3.06	1.64	2.18	1.42
Carotene per gram liver, mcg.	1.75	1.48	2.31	3.11	3.48	1.30	4.67	2.00

[1]Alfalfa hay, $25.00 per ton; sorghum grain, $1.80 per cwt.

[2]5 = moderate, 6 = modest, 7 = small amount, 8 = slight amount, 9 = traces.

Table 11. Results for fattening phase, March 5 to September 25, 1965--204 days. 1964-65 Trial.

Location . . . . :	Colby		Garden City		Manhattan		Mound Valley	
No. steers per lot . . .	6	6	6	6	6	6	6	6
Av. initial wt., lbs. .	615	612	598.2	602.2	620	607.5	662.2	672.2
Av. final wt., lbs. . .	1,110	1,075	1,076.7	1,086.6	1,064.2	1,090	1,037.5	1,065
Av. daily gain, lbs. . .	2.43	2.27	2.35	2.38	2.18	2.37	1.84	1.93
Av. daily ration, lbs.:								
Alfalfa hay	4.90	4.77	4.25	4.93	4.50	5.58	4.81	4.81
Sorghum grain	16.29	16.03	16.03	15.97	16.03	16.51	15.33	16.31
Feed per cwt. gain, lbs.:								
Alfalfa hay	201.88	210.03	181.16	207.77	206.55	235.82	261.19	249.98
Sorghum grain	670.95	705.25	684.40	672.48	736.06	697.93	833.40	846.80
Feed cost per cwt. gain[1]	$14.60	$15.32	$14.58	$14.70	$15.83	$15.51	$18.26	$18.36
Shrink to market, % . .	3.53	2.71	3.79	4.22	2.27	3.06	2.33	5.09
Av. hot carcass wt., lbs.	654.00	645.17	669.83	663.50	653.83	674.67	619.67	638.67
Dressing %, feedlot wt.	58.92	60.02	62.21	61.06	61.44	61.90	59.73	59.97
Dressing %, market wt. .	61.07	61.69	64.67	63.75	62.87	63.84	61.15	63.18
Av. fat thickness, 12th rib	.6	.72	.77	.75	.63	.80	.63	.67
Av. size rib eye sq. in.	11.79	11.39	11.76	11.46	11.27	11.53	11.21	11.13
Av. degree marbling[2] . .	6.67	6.0	4.67	6.0	5.33	5.50	5.83	5.67
Carcass grades:								
Top prime	..	..	1	..	1	..	..	..
Av. prime	..	..	..	..	..	1	..	..
Low prime	..	1	1	..	..	..	..	..
Top choice	..	1	2	4	2	2	4	2
Av. choice	3	2	2	..	1	1	1	3
Low choice	2	1	..	2	2	2	..	1
Top good	1	..	..	..	..	..	..	..
Av. good	..	1	..	..	..	..	1	..

[1]Alfalfa hay $25.00 per ton, sorghum grain $1.80 per cwt.

[2]4 = slightly abundant, 5 = moderate, 6 = modest, 7 = small amount, 8 = slight amount, 9 = trace.

among the other three locations. In the 1964-65 trial, Mound Valley again registered winter gains significantly greater ($P < .05$) than the other three locations. In this trial, Garden City produced gains which were significantly lower ($P < .05$) than all other locations; there were no significant differences between Colby and Manhattan locations. Yearly analysis of variance figures and location means are listed in Tables 12 to 14.

When the three trials were pooled, the analysis of variance detected significant differences due to locations as well as interaction between locations and years. Mound Valley produced significantly highest ($P < .05$) winter gains. Winter gains at Colby were significantly lower than those at Garden City but not significantly lower than those at Manhattan. The difference in gains recorded at Manhattan and Garden City were not significantly different. The significant interaction between locations and years indicates changes in rank among the four locations from year to year with respect to amount of wintering gain achieved. However, the pooled data indicates that, in general, greater wintering gains can be expected to be produced at Mound Valley than at the other locations. Table 15 contains the analysis of variance for the pooled winter gains.

Fattening Gain

Like the wintering gain, two out of the three yearly analyses of variance showed significant difference ($P < .05$) among the locations with respect to fattening gains. Using the Least Significant Difference (LSD), examination of the means showed that significantly lower ($P < .05$) gains were obtained at Mound Valley than at all other stations in the 1962-63 and 1964-65 trials. In both trials, there were no significant differences among the

Table 12. Yearly analysis of variance of wintering gains. 1962-63 Wintering gain.

Source	: d.f.	: M.S.	: F.	: F.05	: Significance
Locations	3	2509.02	7.54	6.59	*
Pens: Locations	4	332.93	0.43	5.71	N.S.
Animals: Pens	40	766.74			

* indicates significance.

N.S. indicates non-significance.

Location Least Significant Difference (LSD) was calculated by

$$t_{.05}\sqrt{\frac{2(P:LMS)}{12}} = 20.62.$$

Location means of wintering gains per steer were as follows:

Colby	128.33
Garden City	137.83
Manhattan	138.33
Mound Valley	162.25.

Table 13. Yearly analysis of variance of wintering gains. 1963-64 Wintering gain.

Source	: d.f.	: M.S.	: F.	: F.05	: Significance
Locations	3	6413.90	3.29	6.59	N.S.
Pens: Locations	4	1944.92	0.27	5.71	N.S.
Animals: Pens	40	7103.90			

Locations means of wintering gains per steer were:

Colby	127.00
Garden City	179.16
Manhattan	159.58
Mound Valley	138.33

Table 14. Yearly analysis of variance of wintering gains. 1964-65 Wintering gain.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	10696.73	79.14	6.95	*
Pens: Locations	4	135.15	0.32	5.71	N.S.
Animals: Pens	40	414.95			

Location Calculated L.S.D. = 13.14.

Location means of wintering gains per steer were:

Colby	138.08
Garden City	124.33
Manhattan	137.91
Mound Valley	191.75

Table 15. Analysis of variance of pooled wintering gains.

Source	d.f.	M.S.	F.	F.05	Significance
Years	2	1089.75	1.35	3.88	N.S.
Locations	3	6567.70	8.17	3.49	*
Years x Locations	6	6525.93	8.11	3.00	*
Pens: Years x Location	12	804.31			
Animals: Pens	120	630.70			

L.S.D. for locations = $t_{.05}\sqrt{\frac{2(P:Y \times LMS)}{36}}$ = 14.58.

Location means of pooled wintering gains per steer were:

Colby	131.14
Garden City	147.11
Manhattan	145.28
Mound Valley	164.11

other three locations. Yearly analysis of variance figures are in Tables 16 to 18.

When the three trials were pooled, the analysis of variance detected significant differences due to locations and years of trials. Mound Valley produced significantly lower ($P < .05$) fattening gains than all other locations. Colby and Garden City had significantly higher gains than Manhattan; there were no significant differences between Colby and Garden City. The significant difference in years of trials indicates variation in the fattening gains from year to year. However, the pooled data indicates that, in general, lower fattening gains can be expected at Mound Valley than at other locations. Table 19 contains the analysis of variance for the pooled fattening gains.

Table 16. Yearly analysis of variance of fattening gains.
1962-63 Fattening gain.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	37618.0	12.20	6.59	*
Pens: Locations	4	3083.17	1.45	5.71	N.S.
Animals: Pens	40	2124.88			

* indicates significance.

N.S. indicates non-significance.

Location Least Significant Difference (LSD) = $t_{.05}\sqrt{\frac{2(P:LMS)}{12}}$ = 62.74

Location means of fattening gains per steer were:

Colby	418.16
Garden City	444.00
Manhattan	399.16
Mound Valley	314.67

Table 17. Yearly analysis of variance of fattening gains. 1963-64 Fattening gain.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	18831.33	4.41	6.59	N.S.
Pens: Locations	4	4265.50	1.18	5.71	N.S.
Animals: Pens	40	3602.32			

Location means of fattening gains per steer were:

Colby	502.17
Garden City	482.83
Manhattan	415.00
Mound Valley	440.42

Table 18. Yearly analysis of variance of fattening gains. 1964-65 Fattening gain.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	25452.00	12.10	6.95	*
Pens: Locations	4	2102.92	0.66	5.71	N.S.
Animals: Pens	40	3164.90			

Location L.S.D. = 51.82

Location means of fattening gains per steer were:

Colby	479.42
Garden City	481.50
Manhattan	463.33
Mound Valley	384.08

Table 19. Analysis of variance of pooled fattening gains.

Source	d.f.	M.S.	F.	F.05	Significance
Years	2	62461.50	19.83	3.88	*
Locations	3	63875.33	20.28	3.49	*
Years x Locations	6	9013.17	2.86	3.00	N.S.
Pens: Years x Location	12	3150.17			
Animals: Pens	120	2964.07			

L.S.D. for Locations = $t_{.05}\sqrt{\frac{2(P:Y \times LMS)}{36}} = 28.85$

Location means of pooled fattening gains per steer were:

Colby	466.58
Garden city	469.44
Manhattan	425.83
Mound Valley	379.72

Total Gain (Wintering Plus Fattening Gains)

The three yearly analyses of variance showed no significant differences among the locations with respect to total gains. Yearly analyses of variance figures are shown in Tables 20 to 22.

However, when the three trials were pooled, the analysis of variance detected significant differences ($P < .05$) due to both locations and years of trials. Garden City had significantly higher total gains than Manhattan and Mound Valley. Colby also had significantly higher gains than Mound Valley. There were no significant differences between Garden City and Colby, Colby and Manhattan, and Manhattan and Mound Valley. The years of trials significance indicated variations in total gains from year to year. However, the pooled data indicate that, in general, higher total gains can be expected to be produced at Garden City than at Manhattan and Mound Valley, but not at

Table 20. Yearly analysis of variance of total gains.
1962-63 Total gain.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	22814.66	5.70	6.59	N.S.
Pens: Locations	4	4000.75	1.22	5.71	N.S.
Animals: Pens	40	3253.55			

N.S. indicates non-significance

Location means of total gains per steer were:

Colby	546.50
Garden City	581.83
Manhattan	537.50
Mound Valley	476.92

Table 21. Yearly analysis of variance of total gains.
1963-64 Total gain.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	21188.66	3.95	6.59	N.S.
Pens: Locations	4	5361.00	1.41	5.71	N.S.
Animals: Pens	40	3788.85			

Location means of total gains per steer were:

Colby	629.17
Garden City	662.00
Manhattan	574.58
Mound Valley	578.75

Table 22. Yearly analysis of variance of total gains. 1964-65 Total gain.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	3703.33	2.09	6.59	N.S.
Pens: Locations	4	1771.25	0.47	5.71	N.S.
Animals: Pens	40	3763.25			

Location means of total gains per steer were:

Colby	617.50
Garden City	605.83
Manhattan	601.25
Mound Valley	575.83

Table 23. Analysis of variance of pooled total gains.

Source	d.f.	M.S.	F.	F.05	Significance
Years	2	79693.50	21.47	3.88	*
Locations	3	36193.00	9.75	3.49	*
Years x Locations	6	5756.67	1.55	3.00	N.S.
Pens : Years x Location	12	3711.0			
Animals: Pens	120	3601.89			

L.S.D. for Locations = $t_{.05}\sqrt{\frac{2(P:Y \times LMS)}{36}} = 31.3$

Location means of pooled total gains per steer were:

Colby	597.72
Garden City	616.55
Manhattan	571.11
Mound Valley	543.83

Colby. Table 23 contains the pooled total gains analysis of variance.

Carcass Characteristics

Carcass Grade. There were no significant differences among the locations shown by the three yearly analyses of variance with respect to carcass grade. Also, when the three trials were pooled, the analysis of variance detected no significant differences in carcass grade due to locations. However, there was a significant difference ($P < .05$) in years of trials, indicating variations in carcass grade from year to year. Tables 24 to 27 contain the analyses of variance for the yearly and pooled carcass grade data. For computation purposes, the following numerical values were assigned to each grade: Prime plus = 9; Prime = 8; Prime minus = 7; Choice plus = 6; Choice = 5; Choice minus = 4; Good plus = 3; Good = 2; and Good minus = 1.

Table 24. Yearly analysis of variance of carcass grade.
1962-63 Carcass grade.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	1.90	0.42	6.59	N.S.
Pens: Locations	4	4.43	2.15	5.71	N.S.
Animals: Pens	40	2.06			

N.S. indicates non-significance.

Location means of carcass grade per steer were:

Colby	4.42
Garden City	3.67
Manhattan	3.83
Mound Valley	3.50

Table 25. Yearly analysis of variance of carcass grade.
1963-64 Carcass grade.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	4.27	1.64	6.59	N.S.
Pens: Locations	4	2.60	1.32	5.71	N.S.
Animals: Pens	40	1.96			

Location means of carcass grade per steer were:

Colby	3.92
Garden City	4.25
Manhattan	3.00
Mound Valley	3.17

Table 26. Yearly analysis of variance of carcass grade.
1964-65 Carcass grade.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	3.58	3.76	6.59	N.S.
Pens: Locations	4	0.95	0.47	5.71	N.S.
Animals: Pens	40	1.98			

Location means of carcass grade per steer were:

Colby	4.58
Garden City	5.83
Manhattan	5.58
Mound Valley	5.16

Table 27. Analysis of variance of pooled carcass grade.

Source	d.f.	M.S.	F.	F.05	Significance
Years	2	40.46	20.43	3.88	*
Locations	3	2.64	1.33	3.49	N.S.
Years x Location	6	3.57	1.80	3.00	N.S.
Pens: Years x Location	12	1.98			
Animals: Pens	120	2.00			

Location means of pooled carcass grade per steer were:

Colby	4.31
Garden City	4.58
Manhattan	4.14
Mound Valley	3.94

Degree of Marbling. The three yearly analyses of variance showed no significant differences among locations with respect to the degree of marbling. Analysis of variance of the pooled data detected no significant differences in the degree of marbling as well. There was, however, a significant difference ($P < .05$) in years of trials, indicating variations in the degree of marbling from year to year. Yearly and pooled data analyses of variance for the degree of marbling are shown in Tables 28 to 31. Numerical values assigned to the different degress of marbling were as follows: 1 = Very abundant; 2 = abundant; 3 = moderately abundant; 4 = slightly abundant; 5 = moderate; 6 = modest; 7 = small amount; 8 = slight amount; and 9 = traces.

Back Fat Thickness. The locations were not significantly different with respect to back fat thickness as shown by the three yearly analyses of variance. However, when the three trials were pooled, the analysis of variance

Table 28. Yearly analysis of variance of degree of marbling. 1962-63 Degree of marbling.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	1.18	0.41	6.59	N.S.
Pens: Locations	4	2.81	2.55	5.71	N.S.
Animals: Pens	40	1.10			

N.S. indicates non-significance.

Location means of degree of marbling per steer were:

Colby	5.92
Garden City	6.67
Manhattan	6.42
Mound Valley	6.42

Table 29. Yearly analysis of variance of degree of marbling. 1963-64 Degree of marbling.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	2.35	4.51	6.59	N.S.
Pens: Locations	4	0.52	0.48	5.71	N.S.
Animals: Pens	40	1.07			

Location means of degree of marbling per steer were:

Colby	7.33
Garden City	6.50
Manhattan	7.25
Mound Valley	7.50

Table 30. Yearly analysis of variance of degree of marbling. 1964-65 Degree of marbling.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	2.47	1.45	6.59	N.S.
Pens: Locations	4	1.70	0.89	5.71	N.S.
Animals: Pens	40	1.89			

Location means of degree of marbling per steer were:

Colby	6.33
Garden City	5.33
Manhattan	5.42
Mound Valley	5.75

Table 31. Analysis of variance of pooled degree of marbling.

Source	d.f.	M.S.	F.	F.05	Significance
Years	2	24.88	14.81	3.88	*
Locations	3	1.16	0.69	3.49	N.S.
Years x Locations	6	2.43	1.45	3.00	N.S.
Pens: Years x Location	12	1.68			
Animals: Pens	120	1.35			

Location means of pooled degree of marbling were:

Colby	6.53
Garden City	6.17
Manhattan	6.36
Mound Valley	6.56

detected significant differences ($P < .05$) due to both locations and years of trials. Mound Valley had significantly lower ($P < .05$) back fat thickness than the other three locations. There were no significant differences among the other three locations. The significance of the years of trials indicates variations in back fat thickness from year to year. However, the pooled data indicate that, in general, lower back fat thickness can be expected at Mound Valley than at Colby, Garden City, and Manhattan. Tables 32 to 35 contain the back fat thickness analysis of variance figures.

Table 32. Yearly analysis of variance of back fat thickness. 1962-63 Back fat thickness.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	.10	3.33	6.59	N.S.
Pens: Locations	4	.03	1.50	5.71	N.S.
Animals: Pens	40	.02			

N.S. indicates non-significance.

Location means of back fat thickness per steer were:

Colby	0.67
Garden City	0.55
Manhattan	0.51
Mound Valley	0.45

Table 33. Yearly analysis of variance of back fat thickness.
1963-64 Back fat thickness.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	.16	2.66	6.59	N.S.
Pens: Locations	4	.06	1.50	5.71	N.S.
Animals: Pens	40	.04			

Location means of back fat thickness per steer were:

Colby	0.71
Garden City	0.76
Manhattan	0.69
Mound Valley	0.50

Table 34. Yearly analysis of variance of back fat thickness.
1964-65 Back fat thickness.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	.03	1.0	6.59	N.S.
Pens: Locations	4	.03	1.0	5.71	N.S.
Animals: Pens	40	.03			

Location means of back fat thickness per steer were:

Colby	0.66
Garden City	0.76
Manhattan	0.72
Mound Valley	0.65

Table 35. Analysis of variance of pooled back fat thickness.

Source	d.f.	M.S.	F.	F.05	Significance
Years	2	0.31	7.20	3.88	*
Locations	3	0.19	4.42	3.49	*
Years x Locations	6	0.05	1.16	3.00	N.S.
Pens: Years x Location	12	0.043			
Animals: Pens	120	0.03			

L.S.D. for Locations = $t_{.05}\sqrt{\frac{2(P:Y \times LMS)}{36}} = 0.106$

Location means of pooled back fat thickness per steer were:

Colby	0.68
Garden City	0.69
Manhattan	0.64
Mound Valley	0.53

Rib Eye Area. The three yearly analyses of variance showed no significant differences among locations with respect to the rib eye area. The analysis of variance of the pooled data detected no significant differences in the rib eye area as well. There was, however, a significant difference ($P < .05$) in years trials, indicating a wide variation in the rib eye area from year to year. Analyses of variance figures are shown in Tables 36 to 39.

Statistical Analysis of Feedstuff

The results obtained by the three yearly analyses of variance on the chemical composition of the feedstuffs used, tabulated in Table 40, indicated that only the protein content of sorghum grain and the carotene content of alfalfa hay were significantly different among the locations.

Table 36. Yearly analysis of variance of rib eye area.
1962-63 Rib eye area.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	1.37	1.53	6.59	N.S.
Pens: Locations	4	0.89	2.17	5.71	N.S.
Animals: Pens	40	0.41			

N.S. indicates non-significance.

Location means of rib eye area per steer were:

Colby	9.86
Garden City	10.46
Manhattan	10.24
Mound Valley	9.72

Table 37. Yearly analysis of variance of rib eye area.
1963-64 Rib eye area.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	0.80	3.47	6.59	N.S.
Pens: Locations	4	0.23	0.24	5.71	N.S.
Animals: Pens	40	0.93			

Location means of rib eye area per steer were:

Colby	11.41
Garden City	11.75
Manhattan	11.13
Mound Valley	11.53

Table 38. Yearly analysis of variance of rib eye area. 1964-65 Rib eye area.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	0.50	2.08	6.59	N.S.
Pens: Locations	4	0.24	0.32	5.71	N.S.
Animals: Pens	40	0.74			

Location means of rib eye area per steer were:

Colby	11.59
Garden City	11.61
Manhattan	11.40
Mound Valley	11.17

Table 39. Analysis of variance of pooled rib eye area data.

Source	d.f.	M.S.	F.	F.05	Significance
Years	2	30.30	65.86	3.88	*
Locations	3	1.42	3.09	3.49	N.S.
Years x Locations	6	0.63	1.37	3.00	N.S.
Pens: Years x Location	12	0.46			
Animals: Pens	120	0.69			

Location means of pooled rib eye area were:

Colby	10.95
Garden City	11.27
Manhattan	10.92
Mound Valley	10.81

Table 40. Summary of statistical analysis of feedstuff chemical composition.

	Moisture	D.M.	Protein	Ash	Crude fiber	Ether extract	N.F.E.	Carotene
Among Locations:								
Silage	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Hay	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
Grain	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	--
Among Years:								
Silage	N.S.	N.S.	N.S.	N.S.	*	N.S.	*	N.S.
Hay	N.S.	N.S.	N.S.	N.S.	*	*	*	N.S.
Grain	N.S.	N.S.	*	*	*	*	N.S.	--

N.S. indicates non-significance.

* indicates significance.

The protein content of sorghum grain at Colby was significantly higher than those at Garden City and Mound Valley. Manhattan sorghum grain protein was significantly higher than that of Garden City and Mound Valley; while that at Garden City was significantly lower than those of the other locations. There was no significant difference between Colby and Manhattan with respect to protein content of the sorghum grain used.

The carotene content of alfalfa hay was significantly higher at Garden City than at the other locations. There were no significant differences among Colby, Manhattan and Mound Valley with respect to the carotene content of alfalfa hay.

There were variations from year to year in the crude fiber and nitrogen free extract content of the silage; crude fiber, ether extract and nitrogen free extract content of the hay; and protein, ash, crude fiber and ether extract content of the grain. Analyses of variance data for each nutrient of the feeds used are shown in Tables 41 to 60.

Table 41. Analysis of variance of silage moisture content.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	16.13	3.75	4.76	N.S.
Years	2	39.35	9.15	5.14	*
Remainder	6	4.30			

Location means were:

Colby	70.62
Garden City	67.26
Manhattan	66.11
Mound Valley	70.63

Table 42. Analysis of variance of silage protein content.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	0.31	1.63	4.76	N.S.
Years	2	0.16	0.84	5.14	N.S.
Remainder	6	0.19			

Location means were:

Colby	1.83
Garden City	1.56
Manhattan	2.31
Mound Valley	2.05

Table 43. Analysis of variance of silage ash content.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	0.23	0.96	4.76	N.S.
Years	2	0.32	1.33	5.14	N.S.
Remainder	6	0.24			

Location means were:

Colby	2.35
Garden City	2.33
Manhattan	1.94
Mound Valley	1.81

Table 44. Analysis of variance of silage crude fiber content.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	2.64	2.56	4.76	N.S.
Years	2	6.00	5.83	5.14	*
Remainder	6	1.03			

Location means were:

Colby	6.18
Garden City	5.43
Manhattan	7.59
Mound Valley	5.85

Table 45. Analysis of variance of silage ether extract.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	.05	2.5	4.76	N.S.
Years	2	.01	.5	5.14	N.S.
Remainder	6	.02			

Location means were:

Colby	0.70
Garden City	0.55
Manhattan	0.82
Mound Valley	0.56

Table 46. Analysis of variance of silage nitrogen free extract.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	12.75	4.43	4.76	N.S.
Years	2	35.57	12.35	5.14	*
Remainder	6	2.88			

Location means were:

Colby	18.34
Garden City	22.87
Manhattan	21.23
Mound Valley	19.10

Table 47. Analysis of variance of silage carotene.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	3.65	.90	4.76	N.S.
Years	2	3.53	.87	5.14	N.S.
Remainder	6	4.05			

Location means were:

Colby	3.76
Garden City	2.02
Manhattan	1.69
Mound Valley	1.24

Table 48. Analysis of variance of hay moisture content.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	1.95	1.55	4.76	N.S.
Years	2	4.45	3.53	5.14	N.S.
Remainder	6	1.26			

Location means were:

Colby	5.34
Garden City	7.03
Manhattan	6.59
Mound Valley	5.58

Table 49. Analysis of variance of hay protein.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	3.03	.30	4.76	N.S.
Years	2	20.53	2.00	5.14	N.S.
Remainder	6	10.24			

Location means were:

Colby	15.40
Garden City	15.64
Manhattan	17.08
Mound Valley	17.40

Table 50. Analysis of variance of hay ash content.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	5.13	2.03	4.76	N.S.
Years	2	6.04	2.39	5.14	N.S.
Remainder	6	2.53			

Location means were:

Colby	7.92
Garden City	9.07
Manhattan	5.97
Mound Valley	7.13

Table 51. Analysis of variance of hay crude fiber.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	1.70	0.22	4.76	N.S.
Years	2	62.20	8.10	5.14	*
Remainder	6	7.68			

Location means were:

Colby	30.12
Garden City	28.28
Manhattan	29.C0
Mound Valley	29.05

Table 52. Analysis of variance of hay ether extract.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	.10	.83	4.76	N.S.
Years	2	1.06	8.83	5.14	*
Remainder	6	.12			

Location means were:

Colby	1.64
Garden City	1.91
Manhattan	2.06
Mound Valley	1.99

Table 53. Analysis of variance of hay nitrogen free extract.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	1.30	0.17	4.76	N.S.
Years	2	68.70	9.09	5.14	*
Remainder	6	7.55			

Location means were:

Colby	39.58
Garden City	38.06
Manhattan	39.31
Mound Valley	38.84

Table 54. Analysis of variance of hay carotene.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	410.08	7.11	4.76	*
Years	2	33.44	0.58	5.14	N.S.
Remainder	6	57.64			

L.S.D. for Locations = $t_{.05}\sqrt{\frac{2(\text{Remainder M.S.})}{3}} = 15.29$.

Location means were:

Colby	17.48
Garden City	33.53
Manhattan	10.98
Mound Valley	6.97

Table 55. Analysis of variance of grain moisture content.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	1.25	0.57	4.76	N.S.
Years	2	4.30	1.97	5.14	N.S.
Remainder	6	2.18			

Location means were:

Colby	10.65
Garden City	11.11
Manhattan	11.81
Mound Valley	10.32

Table 56. Analysis of variance of grain protein content.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	1.08	21.6	4.76	*
Years	2	5.01	100.2	5.14	*
Remainder	6	.05			

L.S.D. for Locations = $t_{.05}\sqrt{\frac{2(\text{Remainder M.S.})}{3}}$ = 0.44.

Location means were:

Colby	9.74
Garden City	8.37
Manhattan	9.43
Mound Valley	8.96

Table 57. Analysis of variance of grain ash content.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	0.28	1.40	4.76	N.S.
Years	2	2.89	14.45	5.14	*
Remainder	6	.20			

Location means were:

Colby	2.21
Garden City	1.54
Manhattan	1.77
Mound Valley	1.60

Table 58. Analysis of variance of grain crude fiber.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	0.14	0.39	4.76	N.S.
Years	2	3.43	9.53	5.14	*
Remainder	6	.36			

Location means were:

Colby	2.19
Garden City	2.03
Manhattan	2.26
Mound Valley	2.55

Table 59. Analysis of variance of grain ether extract.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	.60	.81	4.76	N.S.
Years	2	9.48	12.81	5.14	*
Remainder	6	.74			

Location means were:

Colby	2.53
Garden City	3.57
Manhattan	3.21
Mound Valley	2.86

Table 60. Analysis of variance of grain nitrogen free extract.

Source	d.f.	M.S.	F.	F.05	Significance
Locations	3	2.73	0.57	4.76	N.S.
Years	2	11.75	2.47	5.14	N.S.
Remainder	6	4.75			

Location means were:

Colby	72.67
Garden City	73.38
Manhattan	71.53
Mound Valley	73.69

Statistical Analysis of Climatological Factors

Average climatological data for Colby, Garden City, Manhattan and Mound Valley for the period for the three trials are listed in Tables 61 to 66.

Simple correlation among rainfall, humidity, temperature and average daily gain showed that in 1964-65 wintering phase, humidity was significantly correlated with average daily gain. However, when the wintering phase data was pooled, none of the climatological factors was significantly correlated with average daily gain.

In the fattening phase, there was a significant ($P < .05$) correlation between temperature and average daily gain in 1962-63 as well as in the pooled data for the three years fattening phases. However, only 5.6% of variability in rate of gain could be explained by the temperature-average daily gain correlation. This shows little indication that differences in locations were due to climatological factors of rainfall, humidity and temperature.

Correlation coefficients are listed in Table 67.

Table 61. Average climatological data for Colby, Garden City, Manhattan and Mound Valley. 1962-63 Wintering period (November, 1962 to March, 1963).

Locations	Months	Rainfall (in.)	Relative humidity %	Mean temperature °F.	Average daily gain
Colby	Dec. 1962	0.28	62.50	33.1	1.13
	Jan. 1963	.70	66.70	17.2	0.94
	Feb.	.19	62.50	35.8	1.45
	March	1.84	60.00	41.5	1.09
Garden City	Dec. 1962	0.09	67.70	35.1	1.26
	Jan. 1963	.37	62.70	20.9	1.05
	Feb.	.01	55.70	38.0	1.40
	March	.72	51.70	45.4	1.17
Manhattan	Dec. 1962	0.29	76.20	31.9	1.29
	Jan. 1963	.41	73.00	17.7	1.09
	Feb.	.06	64.20	32.0	1.51
	March	2.06	63.20	45.5	0.86
Mound Valley	Dec. 1962	0.56	72.00	37.8	1.40
	Jan. 1963	1.29	67.00	27.0	1.03
	Feb.	0.01	58.50	37.2	2.40
	March	2.73	59.20	52.2	1.38

Table 62. Average climatological data for Colby, Garden City, Manhattan and Mound Valley. 1963-64 Wintering period (November, 1963 to February, 1964).

Locations	Months	Rainfall (in.)	Relative humidity %	Mean temperature °F.	Average daily gain
Colby	Dec. 1963	0.27	68.75	23.8	1.27
	Jan. 1964	.01	51.50	31.9	1.15
	Feb.	.88	70.75	27.9	0.91
Garden City	Dec. 1963	0.52	65.75	24.8	1.57
	Jan. 1964	.01	48.75	34.4	1.52
	Feb.	1.19	66.50	29.2	1.80
Manhattan	Dec. 1963	0.15	65.25	23.4	1.27
	Jan. 1964	.33	59.50	32.1	0.99
	Feb.	0.80	61.75	32.0	2.16
Mound Valley	Dec. 1963	0.36	70.75	28.7	1.44
	Jan. 1964	.45	56.50	38.2	1.04
	Feb.	.70	62.75	37.6	1.08

Table 63. Average climatological data for Colby, Garden City, Manhattan and Mound Valley. 1964-65 Wintering period (November, 1964 to March, 1965).

Locations	Months	Rainfall (in.)	Relative humidity %	Mean temperature °F.	Average daily gain
Colby	Dec. 1964	0.08	56.50	29.3	1.54
	Jan. 1965	.41	57.25	30.8	0.66
	Feb.	.51	67.50	27.4	1.73
	March	.98	63.75	27.5	1.01
Garden City	Dec. 1964	0.49	71.50	30.3	1.56
	Jan. 1965	.64	67.00	33.4	0.73
	Feb.	.60	71.25	29.2	1.46
	March	.16	59.00	31.6	0.71
Manhattan	Dec. 1964	0.98	72.50	28.0	1.58
	Jan. 1965	1.92	74.00	28.3	1.21
	Feb.	1.51	72.25	26.9	1.34
	March	2.06	69.50	31.2	0.81
Mound Valley	Dec. 1964	1.31	76.25	35.7	2.09
	Jan. 1965	1.97	75.75	38.4	1.55
	Feb.	0.81	72.50	38.4	1.74
	March	1.76	63.25	38.7	1.47

Table 64. Average climatological data for Colby, Garden City, Manhattan and Mound Valley. 1962-63 Fattening phase (March to September, 1963).

Locations	Months	Rainfall (in.)	Relative humidity %	Mean temperature °F.	Average daily gain
Colby	March 1963	1.84	60.00	41.5	1.09
	April	0.05	47.00	54.1	0.58
	May	.70	58.75	63.1	3.85
	June	2.06	51.00	75.2	2.91
	July	4.83	51.75	80.0	1.89
	August	2.60	57.50	76.5	2.03
	Sept.	4.13	68.75	68.8	1.95
Garden City	March 1963	0.72	51.75	45.4	1.49
	April	.05	47.00	56.7	0.37
	May	3.24	59.25	65.8	3.13
	June	3.94	61.25	74.9	4.06
	July	4.58	51.00	81.6	2.22
	August	0.55	53.75	78.6	2.60
	Sept.	1.90	67.75	71.8	1.84
Manhattan	March 1963	2.06	63.25	45.5	0.86
	April	1.47	59.00	56.4	.69
	May	2.06	71.50	64.5	3.23
	June	2.53	68.25	77.1	2.30
	July	1.15	66.50	82.1	2.01
	August	2.01	64.75	79.9	2.06
	Sept.	2.09	68.75	71.6	2.00
Mound Valley	March 1963	2.73	59.25	52.2	1.38
	April	1.09	57.50	63.5	0.35
	May	1.06	68.75	69.0	3.04
	June	4.46	63.75	79.7	1.81
	July	3.52	60.00	82.4	2.02
	August	4.74	59.25	81.6	1.23
	Sept.	1.45	71.75	74.1	1.49

Table 65. Average climatological data for Colby, Garden City, Manhattan and Mound Valley. 1963-64 Fattening phase (March to September, 1964).

Locations	Months	Rainfall (in.)	Relative humidity %	Mean temperature °F.	Average daily gain
Colby	March 1964	0.84	59.50	34.6	1.75
	April	1.28	59.50	49.0	2.89
	May	3.46	55.00	62.2	3.10
	June	1.08	53.50	68.7	2.50
	July	1.84	48.50	80.1	2.06
	August	0.13	48.50	74.0	2.19
	Sept.	2.09	54.00	66.4	2.26
Garden City	March 1964	0.34	52.25	38.9	1.43
	April	.22	54.75	54.6	3.42
	May	4.76	52.75	67.1	3.25
	June	0.90	56.50	72.6	2.25
	July	.91	50.50	82.0	1.88
	August	.32	58.75	76.0	1.84
	Sept.	1.41	65.75	67.7	3.67
Manhattan	March 1964	1.52	59.25	37.7	0.94
	April	4.41	64.50	54.9	3.91
	May	2.52	65.25	68.0	1.83
	June	5.12	75.25	72.1	1.92
	July	3.64	64.25	82.3	1.22
	August	3.22	68.25	74.2	2.44
	Sept.	2.03	76.00	68.6	2.23
Mound Valley	March 1964	1.60	57.50	44.8	1.91
	April	7.26	63.00	62.2	2.93
	May	5.19	64.75	69.8	2.11
	June	7.45	65.00	75.3	2.11
	July	0.85	54.75	83.2	1.84
	August	5.82	67.25	79.1	1.61
	Sept.	0.70	70.25	72.2	2.93

Table 66. Average climatological data for Colby, Garden City, Manhattan and Mound Valley. 1964-65 Fattening phase (March to September, 1965).

Locations	Months	Rainfall (in.)	Relative humidity %	Mean temperature °F.	Average daily gain
Colby	March 1965	0.98	63.75	27.5	1.01
	April	.21	46.75	54.0	2.54
	May	2.03	50.25	63.2	3.22
	June	6.01	69.50	68.8	2.04
	July	5.24	58.50	76.2	1.46
	August	4.23	61.00	72.3	2.43
	Sept.	4.28	76.00	55.6	2.27
Garden City	March 1965	0.16	59.00	31.6	0.71
	April	.16	56.00	55.9	2.62
	May	6.20	63.75	64.5	3.06
	June	6.80	73.50	70.8	2.52
	July	1.57	58.50	78.9	1.83
	August	3.07	61.50	74.3	1.25
	Sept.	4.14	74.00	62.5	2.57
Manhattan	March 1965	2.06	69.50	31.2	0.81
	April	1.48	66.50	55.2	2.48
	May	1.93	66.50	68.1	2.70
	June	12.01	77.25	72.2	2.02
	July	3.66	75.00	77.2	2.51
	August	2.95	70.75	75.8	2.23
	Sept.	8.47	78.50	65.2	2.04
Mound Valley	March 1965	1.76	63.25	38.7	1.47
	April	6.06	66.25	63.9	2.28
	May	6.29	70.50	71.0	1.89
	June	7.66	70.75	75.8	0.89
	July	2.05	60.50	80.9	1.74
	August	4.68	61.75	79.5	1.90
	Sept.	6.64	77.25	72.9	2.15

Table 67. Correlation coefficients among rainfall, humidity, temperature and average daily gain.

1962-63 Wintering phase:			
R	H	.1715	
R	T	.5039*	n = 16
R	A	.3738	
H	T	.5299*	$r_{.05}$ = .468
H	A	.2116	
T	A	.2342	
1963-64 Wintering phase:			
R	H	.5288	
R	T	.0424	n = 12
R	A	.3145	
H	T	.6163*	$r_{.05}$ = .576
H	A	.0357	
T	A	.1511	
1964-65 Wintering phase:			
R	H	.5785*	
R	T	.2896	n = 16
R	A	.0938	
H	T	.1689	$r_{.05}$ = .468
H	A	.5400*	
T	A	.2282	
Pooled data for wintering phase:			
R	H	.2269	
R	T	.3729*	n = 44
R	A	.0755	
H	T	.3297*	$r_{.05}$ = .303
H	A	.1420	
T	A	.1163	
1962-63 Fattening phase:			
R	H	.1273	
R	T	.4837*	n = 28
R	A	.2167	
H	T	.1996	$r_{.05}$ = .374
H	A	.2692	
T	A	.4130*	

Table 67 (concl.).

1963-64 Fattening phase:			
R	H	.4444*	
R	T	.2128	n = 28
R	A	.1036	
H	T	.1007	$r_{.05}$ = .374
H	A	.0398	
T	A	.0218	
1964-65 Fattening phase:			
R	H	.6608*	
R	T	.4711*	n = 28
R	A	.0689	
H	T	.1609	$r_{.05}$ = .374
H	A	.0475	
T	A	.3572	
Pooled data for fattening phase:			
R	H	.5270*	
R	T	.3160*	n = 84
R	A	.0919	
H	T	.1047	$r_{.05}$ = .215
H	A	.0725	
T	A	.2362*	

R = Rainfall

H = Humidity

A = Average daily gain

n = Number of observations

* = Significance

DISCUSSION

The results obtained showed that beef steers in the four locations differed significantly in their weight gains in the wintering and fattening phases as well as in the total gain for the entire experimental period. Statistical analysis of both the feedstuff chemical composition and climatological factors indicated that the significant differences among locations could not be entirely attributed to those factors.

Only the carotene content of alfalfa hay and protein content of sorghum grain were significantly different among locations out of the ration fed. Of the climatological factors considered, the relative humidity was found to be correlated with the average daily gain in the wintering phase of 1964-65 trial but when the data was pooled for the wintering phases of the three years study, no environmental factor was correlated with gains. In the fattening phase, temperature was positively correlated with gains in 1962-63 trial and in the pooled data analysis. Only 5.6% of the variability in the rate of gain could be explained by this correlation with temperature, however. This suggested that there was little indication of differences in gains among locations that were due to climatological factors of rainfall, humidity and temperature.

The differences in weight gains might then be due to varying quantity and proportion of some minerals in the ash content of the ingredients of the ration fed. Toxic minerals, for example, may have harmful effects on the animals and ultimately affect their rate of growth. Interrelationships of minerals in the diet, as well as actual amounts, govern both their usefulness and also their harmful effects. Incorrect proportion of some minerals may affect the availability of others, and consequently have a depressing effect on rate of gain.

Of the carcass characteristics, it was only the back fat thickness that was significantly lower at Mound Valley than at the other locations. The other locations had no significant differences in this respect. A logical explanation for the lower back fat thickness at Mound Valley is that animals there were not as heavy as those from the other locations at the time of slaughter, and their low back fat thickness was just proportional to their body weight. If the weight of Mound Valley animals had been the same as in the others, there probably would not have been any significant difference. The trials, therefore, indicate that the animals did not differ significantly with respect to carcass characteristics irrespective of locations. This result is in agreement with the results obtained by Kuykendall et al. (1964) and Payne and Jacob (1965) who observed that effect of climatic factors on carcass composition was very slight.

In future trials on this project, it is suggested that an ultimate feedstuff analysis be made on the ration used so as to be able to attribute differences in weight gains to specific nutrients. Alternatively, the ration fed to the animals may come from the same source, as a means of standardizing the ration and seeing whether variability in rate of gain in the different locations will be within experimental error of 5.16% which, according to the result of this trial, can be attributed to varying climatic conditions.

As indicated by the result of the three years trials, there was a significant difference in weight gains of beef steers in different parts of the State of Kansas, but the carcass characteristics of the animals did not differ significantly. However, it should be noted that in all locations, satisfactory and economical gains were produced in the three years of the trial.

SUMMARY

Three separate, but identical trials were conducted in 1962-63, 1963-64 and 1964-65 to study the influence of environmental factors on the performance of beef steers, as measured by weight gains and carcass characteristics.

In each trial, 48 Hereford steer calves obtained from the same ranch were divided into four lots of 12 animals each. One lot was assigned to each of four locations at Colby, Garden City, Manhattan, and Mound Valley. The animals in each location were fed locally grown sorghum silage and alfalfa hay in the wintering phase, and sorghum grain and alfalfa hay in the fattening phase.

The results of the wintering phase showed that, in general significantly greater wintering gains can be expected to be produced at Mound Valley than at other locations.

The fattening gains at Mound Valley, however, can be expected to be significantly lower than those at the other locations. The fattening gains at Colby and Garden City were significantly higher than those at Manhattan.

In total gains, the results obtained showed that, generally, significantly higher gains were produced at Garden City than at Manhattan and Mound Valley but not at Colby.

Except for back fat thickness which was significantly lower at Mound Valley than at other locations, carcass characteristics did not differ significantly among the locations.

The results of these trials indicate that content and proportion of minerals and probably factors not measured may account for the differences in performance.

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DEDICATION

To my wife Omotayo and my children Abiola, Abosede, Abioye and Adewale, who did bear my absence from home for four years with dignity and equanimity, in the interest of my academic success, this thesis is dedicated.

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INFLUENCE OF ENVIRONMENTAL FACTORS ON THE PERFORMANCE OF BEEF STEERS

by

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Three separate, but identical trials were conducted in 1962-63, 1963-64 and 1964-65 to study the influence of environmental factors on the performance of beef steers as measured by weight gains, and carcass characteristics.

In each trial, 48 Hereford steer calves obtained from the same ranch (Warner Ranch in Rice County, Kansas) were divided into four lots of 12 animals each. One lot was assigned to each of four locations--Colby, Garden City, Manhattan, and Mound Valley. Each lot was subdivided into two pens of six animals to reduce competition effects and pick up small differences due to treatment. The animals in each location were fed locally grown sorghum silage and alfalfa hay in the wintering phase, and sorghum grain and alfalfa hay in the fattening phase.

Two of the three yearly analyses of variance of the wintering gains showed significantly higher gains for Mound Valley than for other locations. When the three years data were pooled, Mound Valley wintering gains were higher than the other locations. The results of the wintering phase showed that, in general, significantly greater wintering gains can be expected to be produced at Mound Valley than at other locations.

As indicated by the pooled data analysis, the fattening gains at Mound Valley can be expected to be significantly lower than those at the other locations, though only two of the three yearly analyses of the fattening gains were significant. The fattening gains at Colby and Garden City were significantly higher than those at Manhattan.

In total gains, none of the three yearly analyses of variance showed any significant difference among the locations. The pooled data, however, indicated that, generally, significantly higher gains were produced at Garden City than at Manhattan and Mound Valley, but not at Colby.

Back fat thickness was significantly lower at Mound Valley than at other locations. Other carcass characteristics did not differ significantly among the locations.

Feedstuff analyses revealed significant differences in protein content of the sorghum grain and carotene concentration in alfalfa hay. These cannot, however, account fully for the differences in the animal performance, suggesting that if various nutrients are involved, they were not detected by the proximate analysis of the feedstuffs performed.

Correlation of growth data with local rainfall, humidity and temperature suggested that only 5.6% of variability in rate of gain could be explained by the significant correlation of temperature with average daily gain. This showed little indication that differences among locations were due to climatological factors of rainfall, humidity and temperature.

It was noted that in all of the four locations, satisfactory and economical gains were produced in every year of the trials.